

CW 2GeV Linac Error Simulations at 10 mA

80 parameters scanned

Jean-Paul Carneiro

February 11, 2010

Analysis à la M. Baylac / Error Study of CERN LINAC 4 / CARE-Conf-06-007-HIPPI

$$\Delta\epsilon = \frac{\delta\epsilon_{err} - \delta\epsilon_{nom}}{\delta\epsilon_{nom}} \quad (1)$$

- ▶ $\delta\epsilon_{err}$ emittance growth of the beam with errors
- ▶ $\delta\epsilon_{nom}$ emittance growth of the beam without errors

Errors	$\langle \Delta\epsilon_x \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_y \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_z \rangle \pm RMS$ [%]	Lossy runs	Loss Range [%]
Sol. $\delta_{xy} = 150 \mu\text{m}$	10.2 ± 11.1	6.5 ± 4.7	-4.9 ± 3.8	8 / 100	$2.2\text{e-}03$
Sol. $\delta_{xy} = 300 \mu\text{m}$	34.1 ± 36.7	15.9 ± 20.9	-15.6 ± 16.4	56 / 100	$1.3\text{e+}00$
Sol. $\delta_{xy} = 500 \mu\text{m}$	45.0 ± 74.8	8.9 ± 71.4	-41.5 ± 42.6	88 / 100	$1.2\text{e+}01$
Sol. $\delta_{xy} = 750 \mu\text{m}$	-1.3 ± 118.6	-32.0 ± 121.6	-73.8 ± 66.5	97 / 100	$3.7\text{e+}01$
Sol. $\delta_{xy} = 1000 \mu\text{m}$	-6.8 ± 214.3	-32.2 ± 195.5	-69.0 ± 135.4	98 / 100	$5.0\text{e+}01$

Errors	$\langle \Delta\epsilon_x \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_y \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_z \rangle \pm RMS$ [%]	Lossy runs	Loss Range [%]
Sol. $\delta_z = 150 \mu\text{m}$	17.8 ± 17.6	10.2 ± 7.5	-8.3 ± 5.4	34 / 100	7.1e-03
Sol. $\delta_z = 300 \mu\text{m}$	51.3 ± 48.0	18.6 ± 38.6	-30.1 ± 25.9	88 / 100	4.8e+00
Sol. $\delta_z = 500 \mu\text{m}$	-11.4 ± 108.1	-26.7 ± 100.2	-67.8 ± 58.2	92 / 100	3.4e+01
Sol. $\delta_z = 750 \mu\text{m}$	-33.0 ± 121.0	-58.2 ± 131.7	-77.4 ± 78.9	92 / 100	4.6e+01
Sol. $\delta_z = 1000 \mu\text{m}$	-36.1 ± 127.5	-69.2 ± 142.8	-57.8 ± 201.7	92 / 100	4.7e+01

Errors	$\langle \Delta\epsilon_x \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_y \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_z \rangle \pm RMS$ [%]	Lossy runs	Loss Range [%]
Sol. Field $\delta F_{dynamic} = 0.5 \%$	4.8 ± 10.2	8.1 ± 13.6	-0.6 ± 4.7	0 / 100	0.0e+00
Sol. Field $\delta F_{dynamic} = 1.0 \%$	12.0 ± 23.2	26.1 ± 32.8	-0.8 ± 9.1	0 / 100	0.0e+00
Sol. Field $\delta F_{dynamic} = 1.5 \%$	24.2 ± 39.1	56.8 ± 62.5	-1.0 ± 13.0	0 / 100	0.0e+00
Sol. Field $\delta F_{dynamic} = 2.0 \%$	40.7 ± 57.5	99.7 ± 104.2	-1.4 ± 16.1	2 / 100	3.0e-05
Sol. Field $\delta F_{dynamic} = 2.5 \%$	61.8 ± 79.2	153.7 ± 154.9	-1.8 ± 18.4	3 / 100	7.2e-04

Errors	$\langle \Delta\epsilon_x \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_y \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_z \rangle \pm RMS$ [%]	Lossy runs	Loss Range [%]
Sol. Field $\delta F_{static} = 0.5 \%$	2.4 ± 5.8	3.2 ± 7.8	-0.7 ± 3.3	0 / 100	0.0e+00
Sol. Field $\delta F_{static} = 1.0 \%$	4.1 ± 11.8	8.7 ± 15.8	-0.9 ± 6.4	0 / 100	0.0e+00
Sol. Field $\delta F_{static} = 1.5 \%$	7.6 ± 18.6	19.0 ± 25.7	-1.1 ± 9.5	0 / 100	0.0e+00
Sol. Field $\delta F_{static} = 2.0 \%$	13.0 ± 26.3	34.4 ± 39.0	-1.3 ± 12.3	0 / 100	0.0e+00
Sol. Field $\delta F_{static} = 2.5 \%$	20.0 ± 34.5	55.1 ± 57.0	-1.5 ± 14.9	0 / 100	0.0e+00

Errors	$\langle \Delta\epsilon_x \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_y \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_z \rangle \pm RMS$ [%]	Lossy runs	Loss Range [%]
Quads $\delta_{xy} = 150 \mu\text{m}$	6.0 ± 4.4	3.6 ± 1.3	-1.8 ± 1.1	0 / 100	0.0e+00
Quads $\delta_{xy} = 300 \mu\text{m}$	19.1 ± 17.2	7.7 ± 5.2	-4.0 ± 4.1	32 / 100	8.3e-03
Quads $\delta_{xy} = 500 \mu\text{m}$	43.2 ± 50.7	17.5 ± 14.2	-8.5 ± 13.5	65 / 100	1.8e+00
Quads $\delta_{xy} = 750 \mu\text{m}$	41.8 ± 108.6	13.1 ± 51.8	-29.1 ± 35.3	94 / 100	1.7e+01
Quads $\delta_{xy} = 1000 \mu\text{m}$	31.0 ± 112.0	5.8 ± 63.0	-35.8 ± 43.2	96 / 100	2.3e+01

Errors	$\langle \Delta\epsilon_x \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_y \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_z \rangle \pm RMS$ [%]	Lossy runs	Loss Range [%]
Quads $\delta_z = 150 \mu\text{m}$	10.5 ± 9.7	5.6 ± 3.3	-2.4 ± 2.5	9 / 100	1.9e-04
Quads $\delta_z = 300 \mu\text{m}$	37.9 ± 39.4	15.7 ± 12.8	-6.5 ± 9.0	58 / 100	2.3e-01
Quads $\delta_z = 500 \mu\text{m}$	45.1 ± 94.9	15.1 ± 57.8	-23.3 ± 34.7	92 / 100	1.5e+01
Quads $\delta_z = 750 \mu\text{m}$	35.2 ± 99.2	10.9 ± 58.4	-33.4 ± 40.4	93 / 100	2.2e+01
Quads $\delta_z = 1000 \mu\text{m}$	0.3 ± 135.7	-21.0 ± 111.5	-48.2 ± 63.9	95 / 100	3.6e+01

Errors	$\langle \Delta\epsilon_x \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_y \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_z \rangle \pm RMS$ [%]	Lossy runs	Loss Range [%]
Quads $\phi_z = 1$ mrad	2.4 ± 0.1	2.3 ± 0.2	-0.5 ± 0.0	0 / 100	0.0e+00
Quads $\phi_z = 2$ mrad	3.0 ± 0.5	3.0 ± 0.7	-0.5 ± 0.0	0 / 100	0.0e+00
Quads $\phi_z = 5$ mrad	6.8 ± 3.0	7.7 ± 4.0	-0.6 ± 0.3	0 / 100	0.0e+00
Quads $\phi_z = 7$ mrad	11.1 ± 5.8	13.2 ± 7.9	-0.6 ± 0.5	0 / 100	0.0e+00
Quads $\phi_z = 10$ mrad	20.2 ± 11.7	24.9 ± 16.0	-0.7 ± 1.0	0 / 100	0.0e+00

Errors	$\langle \Delta\epsilon_x \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_y \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_z \rangle \pm RMS$ [%]	Lossy runs	Loss Range [%]
Quads Field $\delta F_{dynamic} = 0.5 \%$	8.4 ± 13.1	6.9 ± 9.9	-0.8 ± 3.2	0 / 100	0.0e+00
Quads Field $\delta F_{dynamic} = 1.0 \%$	30.3 ± 30.2	23.1 ± 25.7	-1.0 ± 6.3	0 / 100	0.0e+00
Quads Field $\delta F_{dynamic} = 1.5 \%$	68.0 ± 55.7	51.9 ± 51.5	-1.4 ± 9.4	3 / 100	2.8e-04
Quads Field $\delta F_{dynamic} = 2.0 \%$	120.3 ± 89.6	94.2 ± 88.2	-1.9 ± 12.4	11 / 100	4.4e-03
Quads Field $\delta F_{dynamic} = 2.5 \%$	183.9 ± 128.4	149.8 ± 135.3	-2.6 ± 15.2	19 / 100	2.4e-02

Errors	$\langle \Delta\epsilon_x \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_y \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_z \rangle \pm RMS$ [%]	Lossy runs	Loss Range [%]
Quads Field $\delta F_{static} = 0.5 \%$	5.2 ± 8.0	5.1 ± 5.9	-0.4 ± 1.5	0 / 100	0.0e+00
Quads Field $\delta F_{static} = 1.0 \%$	13.0 ± 17.3	12.5 ± 13.9	-0.3 ± 3.0	0 / 100	0.0e+00
Quads Field $\delta F_{static} = 1.5 \%$	25.8 ± 29.5	24.6 ± 25.4	-0.2 ± 4.6	0 / 100	0.0e+00
Quads Field $\delta F_{static} = 2.0 \%$	43.6 ± 45.4	41.9 ± 40.8	-0.1 ± 6.2	1 / 100	1.0e-05
Quads Field $\delta F_{static} = 2.5 \%$	66.3 ± 65.1	64.8 ± 60.4	-0.1 ± 7.9	4 / 100	1.3e-04

Errors	$\langle \Delta\epsilon_x \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_y \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_z \rangle \pm RMS$ [%]	Lossy runs	Loss Range [%]
Cav. $\delta_{xy} = 150 \mu\text{m}$	2.5 ± 0.2	2.2 ± 0.2	-0.7 ± 0.1	0 / 100	0.0e+00
Cav. $\delta_{xy} = 300 \mu\text{m}$	2.9 ± 0.7	2.7 ± 0.6	-0.9 ± 0.3	0 / 100	0.0e+00
Cav. $\delta_{xy} = 500 \mu\text{m}$	3.9 ± 1.7	3.8 ± 1.2	-1.5 ± 0.9	0 / 100	0.0e+00
Cav. $\delta_{xy} = 750 \mu\text{m}$	6.3 ± 3.8	5.8 ± 2.5	-2.5 ± 1.8	1 / 100	1.0e-05
Cav. $\delta_{xy} = 1000 \mu\text{m}$	9.7 ± 6.6	8.7 ± 4.3	-3.7 ± 3.1	3 / 100	1.4e-04

Errors	$\langle \Delta\epsilon_x \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_y \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_z \rangle \pm RMS$ [%]	Lossy runs	Loss Range [%]
Cav. $\delta_z = 150 \mu\text{m}$	4.4 ± 4.7	2.7 ± 5.7	2.7 ± 12.9	0 / 100	0.0e+00
Cav. $\delta_z = 300 \mu\text{m}$	13.1 ± 15.0	5.9 ± 11.8	12.5 ± 26.8	0 / 100	0.0e+00
Cav. $\delta_z = 500 \mu\text{m}$	35.0 ± 33.2	15.5 ± 22.0	34.1 ± 47.5	1 / 100	1.0e-05
Cav. $\delta_z = 750 \mu\text{m}$	72.8 ± 60.2	36.3 ± 39.6	91.7 ± 138.5	13 / 100	9.7e-04
Cav. $\delta_z = 1000 \mu\text{m}$	83.8 ± 62.5	49.1 ± 48.5	102.5 ± 140.4	18 / 100	2.9e-03

Errors	$\langle \Delta\epsilon_x \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_y \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_z \rangle \pm RMS$ [%]	Lossy runs	Loss Range [%]
Cav. $\phi_z = 1$ mrad	2.2 ± 0.0	2.1 ± 0.0	-0.5 ± 0.0	0 / 100	0.0e+00
Cav. $\phi_z = 2$ mrad	2.2 ± 0.0	2.1 ± 0.0	-0.5 ± 0.0	0 / 100	0.0e+00
Cav. $\phi_z = 5$ mrad	2.2 ± 0.0	2.1 ± 0.0	-0.5 ± 0.0	0 / 100	0.0e+00
Cav. $\phi_z = 7$ mrad	2.2 ± 0.0	2.1 ± 0.0	-0.5 ± 0.0	0 / 100	0.0e+00
Cav. $\phi_z = 10$ mrad	2.2 ± 0.1	2.1 ± 0.0	-0.5 ± 0.0	0 / 100	0.0e+00

Errors	$\langle \Delta\epsilon_x \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_y \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_z \rangle \pm RMS$ [%]	Lossy runs	Loss Range [%]
Cav. Phase $\delta\phi_{dynamic} = 0.5^\circ$	39.7 ± 37.9	7.4 ± 19.0	13.9 ± 30.7	0 / 100	0.0e+00
Cav. Phase $\delta\phi_{dynamic} = 1.0^\circ$	121.7 ± 95.8	29.3 ± 47.6	53.7 ± 79.8	1 / 100	1.0e-05
Cav. Phase $\delta\phi_{dynamic} = 1.5^\circ$	142.0 ± 112.3	40.5 ± 56.1	90.2 ± 140.3	3 / 100	2.1e-04
Cav. Phase $\delta\phi_{dynamic} = 2.0^\circ$	157.2 ± 118.7	61.3 ± 102.3	207.0 ± 568.6	12 / 100	1.6e-03
Cav. Phase $\delta\phi_{dynamic} = 2.5^\circ$	200.5 ± 466.0	88.0 ± 224.0	4792.7 ± 43745.4	20 / 100	4.0e-01

Errors	$\langle \Delta \epsilon_x \rangle \pm RMS$ [%]	$\langle \Delta \epsilon_y \rangle \pm RMS$ [%]	$\langle \Delta \epsilon_z \rangle \pm RMS$ [%]	Lossy runs	Loss Range [%]
Cav. Field $\delta F_{dynamic} = 0.5\%$	45.6 ± 38.2	9.5 ± 18.0	8.2 ± 24.1	0 / 100	0.0e+00
Cav. Field $\delta F_{dynamic} = 1.0\%$	124.9 ± 91.8	30.1 ± 46.9	36.7 ± 63.2	1 / 100	3.0e-05
Cav. Field $\delta F_{dynamic} = 1.5\%$	183.5 ± 107.9	58.1 ± 74.9	202.2 ± 480.9	11 / 100	3.0e-03
Cav. Field $\delta F_{dynamic} = 2.0\%$	200.2 ± 113.0	68.2 ± 92.5	300.3 ± 660.6	18 / 100	1.6e-02
Cav. Field $\delta F_{dynamic} = 2.5\%$	288.2 ± 946.6	134.5 ± 671.4	44076.2 ± 436751.2	23 / 100	9.9e-01

Errors	$\langle \Delta\epsilon_x \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_y \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_z \rangle \pm RMS$ [%]	Lossy runs	Loss Range [%]
Cav. Phase $\delta\phi_{static} = 0.5^\circ$	15.1 ± 16.1	5.3 ± 9.4	1.8 ± 17.1	0 / 100	0.0e+00
Cav. Phase $\delta\phi_{static} = 1.0^\circ$	46.3 ± 44.7	13.9 ± 23.6	12.8 ± 38.4	0 / 100	0.0e+00
Cav. Phase $\delta\phi_{static} = 1.5^\circ$	86.3 ± 73.2	28.6 ± 41.4	35.4 ± 79.1	0 / 100	0.0e+00
Cav. Phase $\delta\phi_{static} = 2.0^\circ$	124.4 ± 92.6	47.8 ± 58.7	95.1 ± 272.3	4 / 100	1.0e-04
Cav. Phase $\delta\phi_{static} = 2.5^\circ$	135.7 ± 99.2	55.9 ± 65.8	110.9 ± 278.5	5 / 100	1.3e-04

Errors	$\langle \Delta\epsilon_x \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_y \rangle \pm RMS$ [%]	$\langle \Delta\epsilon_z \rangle \pm RMS$ [%]	Lossy runs	Loss Range [%]
Cav. Field $\delta F_{static} = 0.5 \%$	15.2 ± 14.0	3.5 ± 6.6	3.4 ± 9.8	0 / 100	0.0e+00
Cav. Field $\delta F_{static} = 1.0 \%$	49.6 ± 42.6	8.8 ± 17.1	15.0 ± 25.6	0 / 100	0.0e+00
Cav. Field $\delta F_{static} = 1.5 \%$	93.3 ± 72.6	18.5 ± 32.7	37.4 ± 67.9	0 / 100	0.0e+00
Cav. Field $\delta F_{static} = 2.0 \%$	135.7 ± 92.1	32.1 ± 49.6	93.3 ± 237.0	3 / 100	6.0e-05
Cav. Field $\delta F_{static} = 2.5 \%$	152.7 ± 104.8	43.2 ± 78.0	139.0 ± 395.0	8 / 100	3.0e-04